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GROWTH AND UNEMPLOYMENT:

UNDERSTANDING OKUN'S LAW FOR PORTUGAL

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Abstract

The goal of this research project is to study Okun's Law for Portugal. This concept describes the relationship between GDP and unemployment. Through a Rolling Windows methodology it was possible to conclude that this relationship has not been stable and the correlation has been increasing over the years. There is also evidence of higher correlation during periods where GDP has grown less than the previous period. Nowadays, 1% GDP annual growth leads to a fall in the unemployment rate around 0.36%. Moreover, the information collected by this relationship is useful for short-run forecasting purposes.

Keywords: GDP growth, Unemployment, Portugal, Okun's Law

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Introduction

If there are variables that are unarguably in the heavyweight category in Economics, they are GDP and Unemployment. While the output captures how much is being produced in the economy, the unemployment contains information regarding the resources that are idle, in particular in the workforce. Thereupon, the link between these two variables is straightforward and a negative relationship between them is always expected to be observed. Nonetheless the behavior of such correlation incorporates so many factors that in order to fully understand it further analysis is required. Notwithstanding the fact a vast amount of research was already performed, for Portugal the literature is rather short. Thus with the goal of tackling this issue, a considerable part of this study will consist in exploring how the relationship behaves over time and try to find some insights on how it works for the Portuguese economy. Additionally, the comprehension of such relationship may also provide useful information to the policy-makers. On one side, by giving information about the impact of a certain policy, for instance, if a policy has the goal of changing growth in a certain value, how that change is going to affect unemployment. On the other side, by adding the information about the relationship in the models, it may generate better forecasts, which in turn will lead to better targeted and appropriated policies.

The first section will describe the existing literature. Section II introduces the data used, while section III provides a thorough explanation of the methodology employed through the project. After all the computations made, the results are presented in section IV, followed by its respective analysis. The last part of the project will be section V, whereas the main conclusions and discussion are presented.

I - Literature review

The relationship between output and idle resources has always been a subject of intense research, especially in the labor market whereby idle resources one means unemployed people. Half a century ago, Arthur Okun (1962) discovered that a three percent change in output leads to an one percent change in the unemployment rate – Okun's Law. This pioneer study has become the grounding of an extensive amount of literature due to two major reasons – on one hand it is simple and parsimonious and on the other hand has proven to fit the US data throughout the years.

Although as any time series, variables and their relationships change and what was true yesterday may not be the case today. Actually postwar recessions were a sign and a reason to review Okun's rule of thumb and check its suitability through the new data. An extensive amount of new research emerged, mainly regarding the stability of the law. In fact there is already a vast number of authors that argue in favor of Okun's Law instability, even though the reasoning and facts presented vary across authors and methodologies. Weber (1995), Knotek (2007), Lee (2000), Harris and Silverstone (2001) and many others found that Okun's law is a nonlinear relationship. IMF (2010), Meyer and Tasci (2012) and Owyang and Sekhposyan (2012) go a bit further on the issue and show that Okun's coefficient is sensitive to business cycles and changes differently whenever the cycle is in a contraction or expansion – the absolute value of the coefficient is bigger (smaller), during recession (expansion) periods. Moreover these three studies already take into account data regarding the great recession and describe that period as an evidence of the mentioned relationship instability. Other line of thought introduces "jobless recoveries" as an explanation for the break in the law. This idea states that the revival of output growth, in the end of a recession, happens through an increase in productivity but with a continuing decline in employment. For instance in favor of this concept, Gordon (2010) arguments that Okun's law is obsolete from 1986 onwards and that productivity no longer presents signs of procyclical fluctuation, which in turn, tears apart RBC's "technological shocks" and therefore the whole theory supporting it. Furthermore Mckinsey (2010) defends the same idea but introduces that the labor market has changed over the last years and to recover employment not only output growth has to increase but also reforms in the labor market have to occur.

Arguing the opposite, Ball et al. (2013) and Galí et al. (2012) argue that Okun's rule of thumb has been stable over the years and remains a good forecasting tool. They disavow "jobless recovery" by arguing that employment is recovering more slowly due to the mild recoveries of output in postwar recessions, in comparison to the first half of the century. Additionally, the stability of the law is an important issue for policy-makers because forecasts tend to be more accurate if the relationship between output and unemployment is stable. Nevertheless, although stability is a good and desirable feature, it does not mean that forecasts are worthless when those characteristics are not verified. For instance, Knotek (2007) besides replicating Okun's models also compares several forecasting models and reach the conclusion that even though the relationship is not constant over the years, an Okun's model provides better forecasts than simple autoregressive models. Other issue of interest is to understand how Okun's coefficient behave across countries. The literature in this subject is consistent – Countries exhibit different types of relationship between output and unemployment and therefore different coefficient values. Ball et al. (2013) found that the coefficient varies substantially across countries and that the variation is partly explained by idiosyncratic features of the labor markets and not by Employment Protection Legislation (EPL).[2] Contrary, Cazes et al. (2013) and IMF (2010) find the same cross-country difference but conclude that EPL has an important role explaining the different coefficients – the responsiveness of the unemployment rate is lower in countries where EPL is bigger. Whilst the major part of these studies are about the US economy, ECB (2012) investigates the labor markets for the Euro Area (EA) economies during the crisis and find that downward wage rigidities and labor market segmentation amplify the impact of the crisis in employment.[3]

II - Data

As previously mentioned, real GDP[4] and the unemployment rate[5] were the two series employed in the study. The output series was obtained from the OECD database and the unemployment rate from AMECO, both for quarterly (1999Q1-2013Q2) and annual (1974-2012) and seasonally adjusted data. As suggested by the literature and since both variables are not stationary, the series were transformed into real GDP growth (g) and changes in unemployment rate (Δu).[6] When looking to the Portuguese history it is plausible to question the existence of structural changes in the data. Firstly, since 1974 there were three IMF interventions in the country and three major crises in the developed economies (Oil crisis, Dot-com bubble and Subprime crisis). Additionally, Portugal joined the European Economic Community (EEC) in 1986 and the European Monetary Union in 1999, whereas both events were key turning-points in the change of paradigm, either in the availability of instruments as in the goals pursued by policy-

[2] EPL measures the costs involved in dismissing and hiring workers.
[3] Since the cross-country comparison has been studied by a vast number of authors, it was decided not to approach this topic in this project.
[4] In millions of US dollars, constant prices and PPPs.
[5] Unemployment rate is the percentage of total labor force that is unemployed but actively seeking employment and willing to work.
[6] The non stationarity of the series was confirmed by unit root tests.

makers.[7] Last but not least, the structure and composition of the labor market also changed. In fact, while in early 80s, contractual rigidity and wages increased significantly, nowadays the process is reverse, wages are decreasing and contracts are starting to be more flexible. That said, before computing any regressions, it is crucial to analyze both series and check for any problems that may affect the credibility and strength of the results, such as structural breaks. As will be demonstrated later, the dates where the structural changes occur in the relationship between the variables are in 1980 for annual data and in the first quarter of 2009 for quarterly data.[8]

In a second stage of the research, will be used as a leading indicator of GDP growth the Consumer Confidence Index (CCI). This series was provided by the National Statistical Institute of Portugal (INE), for the same quarterly temporal range and it measures how pessimistic or optimistic the population is regarding the economic situation in the near future.[9]

III – Methodology

In this section after a brief introduction of Okun's Law, it will be described the three models used, the procedures employed to analyze the stability and lastly the methods to forecast and how to compare them.

Okun's Law

Initially this topic was studied based on long-run relationships, whereas on one side, potential output is determined by production capacity, factor accumulation and technological changes and on the other side, the natural unemployment rate is

[7] Amaral (2010) provides a thorough analysis on the Portuguese economy since the Carnation Revolution in 1974.
[8] The periods where the breaks occur are not comparable because the datasets have different periodicities and ranges.
[9] Other variables such as Industrial Production Index (IPI), Composite Leading Indicator (MEI) and Economic Sentiment Indicator (ESI) were tested, but in the end did not perform as well as CCI.

determined by labor force and market frictions. The link between these two worlds occurs through shifts in the aggregate demand, which cause the output to fluctuate and then changing unemployment through adjustments in hiring and firing by the firms. Thereupon, Okun's coefficient is affected by almost everything in the markets, mainly the labor one. It depends on costs of adjusting, training, employment protection laws, labor force, minimum wage, etc.

Although describing potential output and natural unemployment rate is an appealing idea in theory, in practice they lack of true meaning, in the sense that, they are not observable and there is not a consensus on how to compute them. Beyond that it is still possible to analyze how output and unemployment correlation changes over time without using those "long-term" variables. This research project will only use models with real GDP growth (g) and changes in unemployment rate (Δu), avoiding then the uncertainty and inaccuracy associated with the unobservable variables. Further, in order to explore how the relationship behaves over time and its usefulness for forecasting purposes, it is crucial to find models that describe it in the most credible way, so the coefficient analysis will be more trustworthy and the forecasts will produce smaller errors.

The static model

This first model captures the contemporaneous correlation between changes in unemployment (Δu) and real output growth (g), i.e. how unemployment rate moves contemporaneously whenever real growth varies and corresponds to model 1 in Okun (1962):

$$\Delta u_t = \alpha + \beta g_t + \delta D_t^{2009Q1} + \varepsilon_t \qquad (1)$$

The coefficient α is a constant term and can be interpreted as the change in unemployment rate when growth is null. The parameter β is often called "Okun's coefficient" and is expected to have a negative value, capturing the negative relationship between unemployment and GDP growth. Thus if the economy grows 1%, the unemployment rate will change by β%. Moreover the ratio $-\frac{\alpha}{\beta}$ gives the growth rate at which unemployment rate is stable. δ is the coefficient of a dummy variable D_t^{2009Q1} which tackles the structural break occurring in the first quarter of 2009[10] and ε is an error term.

The dynamic model

Since the first model only captures contemporaneous correlations, it may be also important to include some dynamic components, i.e. past GDP growth having an impact on current unemployment. One of the arguments in favor of this idea is the previously mentioned "jobless recovery". If the latter holds, it means that after a recession the recovery of employment lags the recovery of output and thus both employment and unemployment will not depend only on current output but also on past output values. Moreover, despite this reasoning, since the point here is to find the best model possible it is interesting and tenable to analyze how unemployment reacts to output over time. In line with this idea, the second model applied will be a Polynomial Distributed Lag model (PDL), introduced by Almon (1965):

$$\Delta u_t = \alpha + \sum_{j=0}^{4} \gamma_j g_{t-j} + \delta D_t^{2009Q1} + \varepsilon_t \qquad (2)$$

This model implies a restriction in the shape of the impulse-response function which will lie on a polynomial:

[10] D_t^{2009Q1} equals 0 before the first quarter of 2009 and 1 afterwards.

$$\gamma_j = \omega_0 + \omega_1 j + \omega_2 j^2 \qquad (3)$$

In this particular case and by using Schwarz Information Criteria to find the optimal degree, it will be a polynomial of second degree with four lags. In addition, it was imposed a restriction that the far-end coefficient will be zero, meaning that the impact of GDP growth on unemployment will vanish over time. The main reason of using this model is, on one hand to capture all the dynamics between the relationship of the variables and on the other hand, avoid to lose degrees of freedom by introducing more lagged variables. However, it is important to be careful when interpreting the coefficients, thus even though they can be interpreted, they are still an image of the predetermined polynomial . Nonetheless it is still a fruitful model to analyze the overall impacts and to produce forecasts.

The VAR model

The last model will be a multivariate VAR model. In this kind of approach, both variables are treated symmetrically and are expressed by an equation that explains its evolution through lags of other variables and its own past. A VAR model of order one can be written in matrix format as:

$$\begin{bmatrix} \Delta u_t \\ g_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} \Delta u_{t-1} \\ g_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad (4)$$

Where the α's and β's are coefficients to estimate, Δu and g are variables and the ε's are error terms. The number of lags used was decided taking into account the lag length criteria, which pointed to zero or one lags.[11] Since the goal here is to analyze the dynamics between variables over time and its forecasting power, was decided to use a

[11] While the Akaike Information Criteria pointed to an optimal one lag, Schwarz Information Criteria describes zero has the optimal scenario. In this case, the information criteria followed was the Akaike one.

VAR of order one.[12] The main advantage of using this model is the capacity to analyze the effects of the variables in each other over the time, without defining causalities a priori.

Stability

In what regards stability, besides graphical analysis and structural break tests of the series,[13] the main tool used is going to be the Rolling Windows method. The latter consists in running a regression over different subsamples in order to analyze how the coefficients change over time. As the goal here is a more long-run analysis, annual data from 1974 to 2012 will be used. Additionally, due to the small amount of observations available, the regression employed will be a transformation of the static model (1). To analyze the stability of a relationship, it does not make sense to include components which already tackle the changes in the relationship, thus this modified version will be exactly the same as the static model (1) but without the dummy variable. Moreover the window of each subsample will be of 20 observations.[14] A additional detail in this matter is how to frame each regressed coefficient for a specific year. Since whenever is used OLS to regress a linear model, the computed coefficient is a representation of all the observations in the sample, it is plausible to assume that in any year of the sample, the coefficient is a proper indicator of the relationship. Therefore, to construct an analysis based on the recent years, each coefficient will be associated with the last observation of each sample. Thus when associating the coefficient values for a certain period, has to be taken into consideration that, it may not represent exactly that period,

[12] For that same reason, it was not included the structural break of 2009Q1. With the inclusion of the dummy variable, the lag criteria indicated zero lags, which for this particular purpose is not interesting.

[13] The two tests employed are the ones presented by Bai-Perron (2003) (BP) and Chow (1960). In BP test the definitions are trimming of 0.15, allowing for 5 breaks and global information criteria using Schwarz criterion.

[14] The first regression is from 1974 to 1993, the second from 1975 to 1994 and so forth. With the assumption of using the last value of each sample, the range of coefficients will be from 1992 until 2012.

but the group of periods nearby. Lastly, given that this procedure produces series of coefficients over time, it enables the construction of series such as break-even GDP growth or in other words the level of growth required to have a stable unemployment rate for each period.

Forecasting

As previously mentioned, the models used in the forecasting comparison analysis will be (1), (2), and (4). In addition, an autoregressive-moving-average model (ARMA) with an exogenous component, which will serve as baseline model:

$$\Delta u_t = \alpha + \beta_1 \Delta u_{t-1} + \beta_2 \Delta u_{t-2} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \delta D_t^{2009Q1} + \varepsilon_t. \qquad (5)$$

In this model, changes in unemployment are explained by a constant term, changes in unemployment in previous quarters, a dummy variable tackling the structural break of the first quarter of 2009 and contemporaneous and past error terms. The number of lags decided are in line with Schwarz Information Criteria, coefficient significance and no serial correlation in the residual. The type of forecasting procedure that is going to be followed is the one-step ahead method, in which to forecast the changes in unemployment rate in period t+1, all the information available until t is used. Since model (1) and (2) use contemporaneous information about growth, when forecasting changes in unemployment rate, it is necessary to forecast these growth contemporaneous values as well. In order to do it, two different models were estimated:

$$g_t = \alpha + \beta_1 CCI_{t-1} + \varepsilon_t \qquad (6)$$

$$g_t = \alpha + \beta_1 g_{t-1} + \theta_1 \varepsilon_{t-1} + \delta D_t^{2008Q1} + \varepsilon_t \qquad (7)$$

In model (6) GDP growth is explained by a constant term, the Consumer Confidence Index (CCI) lagged one period and an error term. Model (7) is similar to (5), but only including one lagged period information (ARMA(1,1)), using growth instead of changes in unemployment rate and the dummy variable correspondent to the break in growth series.[15] The reason why these were the chosen models is, on one side they allow to find if past values are important or not. While model (1) only captures the contemporaneous relationship, model (4) captures only the importance of lagged values and (2) captures both contemporaneous and past. On the other side, due to the fact that the number of observations is short, all the three models should be simple and parsimonious, which is a common characteristic in both three models. The range of forecasts and forecasting errors will be from the second quarter of 1999 until the second quarter of 2013.[16] Since the point here is not use the forecasts, but rather to check how good the models perform when forecasting, the focus will be on comparing the forecasting errors between models. Particularly, finding if the models (1), (2) and (4) can provide short-run forecasts with smaller errors than (5) and if so, endorsing the idea that Okun's law is a good forecasting tool. To perform this comparison two concepts will be used, Mean Square Prediction Error (MSPE) and Diebold-Mariano test (DM):

$$MSPE = \frac{\left[\sum_{t=1}^{n}(\Delta u_t - \widehat{\Delta u}_t)^2\right]}{n} \qquad (8)$$

$$DM = \frac{\bar{d}}{\sqrt{VAR(\bar{d})}} \sim N(0,1) \qquad (9)$$

where $d_t = (\Delta u_t - \widehat{\Delta u}_{Baseline\,,t})^2 - (\Delta u_t - \widehat{\Delta u}_{model\,X,t})^2$ and $\bar{d} = \frac{\sum_{t=1}^{n} d_t}{n}$

[15] This dummy was computed through the analysis of the results of a BP structural break test for the quarterly GDP growth series.

[16] As in the Rolling Windows procedure, the base sample will be 20 observations.

MSPE is the sum of the squared difference between the actual values and the forecasts divided by the number predictions computed, i.e. it measures the average squared distance between what a model predicts a specific value and what the true value is. Although with MSPE it is possible to rank the models, it does not introduce much information about if that differences are statistically significant. Then to deal with this issue DM test is introduced. This test follows a standardized normal distribution and it is the average of the squared difference of the errors of two models, or in other words, it compares the forecasting accuracy between two models.[17] In DM test, the null hypothesis states that the two models have equal forecast accuracy in terms of mean squared loss. When rejecting the null hypothesis it means that the models performed differently and the one with lower MSPE is the one that provides better forecasts.

IV - Results

Stability

As suggested in the Data section, Portugal went through an immense amount of critical moments during its history, which in turn have caused severe changes in the relationship between variables and if not taken into consideration will affect the credibility and strength of the results. To explore more closely this issue, BP test was computed for structural changes in the intercept (α) and the consequent results are shown in table 1. These findings are consistent with the existence of structural changes

Table 1: Estimated break dates from BP test

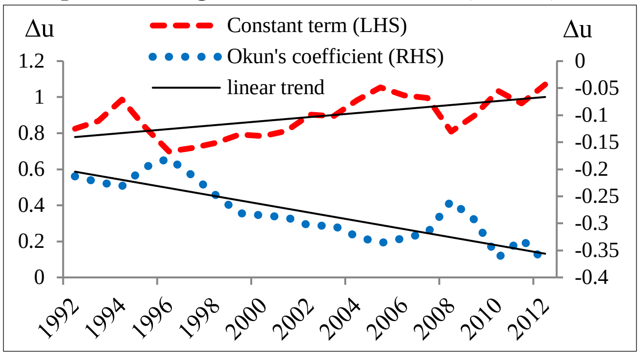
Model	Annual Data	Quarterly Data
$g_t = \alpha + \varepsilon_t$	2002***	2008Q1**
$\Delta u_t = \alpha + \varepsilon_t$	2002**	2009Q1***
$\Delta u_t = \alpha + \beta(g_t) + \varepsilon_t$	1980*	2009Q1***

*p<0.05, **p<0.01, ***p<0.001 (p-values for Chow test)

[17] Since the point is to compare (1), (2) and (4) with the baseline model (5), the model from the left-hand side in the equation will always be (5).

and reinforced by similar results when performing Chow test, where all the p-values are lower than 5%. Furthermore it is important to highlight that a structural break in the series does not directly mean a change in the relationship of the variables, meaning if both variables have a structural break at the same period and with the same dimension, it is possible that the relationship remains unchanged. This is why the 2002 break in both variables was not translated into a relationship break, whilst in 1980, none of the variables had a break but it exhibits a break in the relationship. Hereupon, in the end what really matters for computational purposes is the existence of breaks in the relationship, which when writing the regressions it has to be taken into consideration. [18]

Graph 1: Rolling Windows coefficients (annual)



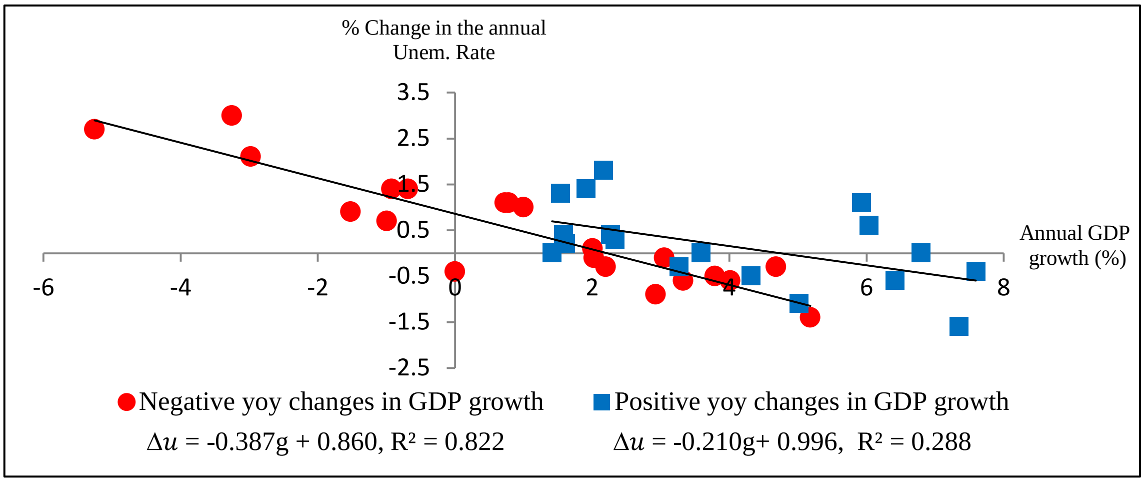
At this point it is reasonable to argue against the stability of Okun's Law over the years, at least, it is towards this idea that the historical events and the structural break tests indicate. Notwithstanding it is still interesting to further explore the issue and find what can affect this instability. For example, imagine the case of having a gradual change in the correlation instead of having a structural break. In that scenario the results would be misleadingly interpreted by the structural break tests as one single period break or not taken into consideration at all. In order to avoid this problem, the Rolling Windows procedure is a key instrument to analyze how the coefficients behave over time and its results are shown in graph 1. In the latter each line represents the value of the

[18] Even though BP test captures more than one break, using Schwarz Information Criteria, for both series and their relationship the number of changes was always one.

coefficients throughout the years. On one hand, Okun's coefficient demonstrates a negative trend, changing from around -0.213 to thereabout -0.370 in 20 years. In other words, 20 years ago, if GDP fell 1%, it would mean an average reduction in unemployment of 0.213%, while nowadays the same GDP growth would be translated into an average fall in unemployment of 0.370%. On the other side, the constant term, which gives how much does the unemployment rate changes every year if GDP growth is zero, also shows signs of a trend, but in this case, a positive one. A similar interpretation can be taken for this coefficient, if 20 years ago, with a null growth, the annual unemployment rate would increase on average, 0.825%, in the recent years it would increase around 1.070%. These values clarify two main ideas about the relationship between the unemployment rate and GDP growth. Firstly, there was a significant increase in the impact that GDP growth has in the unemployment rate, thus Okun's coefficient almost doubled and an unstable relationship is evident over the sample. Secondly, through the analysis of the constant term one can retain that the unemployment rate has been in a positive trend.

So far it is clear that the relationship has been unstable and there is an increasing correlation between the variables. Nevertheless and not suppressing the importance of these findings, one final idea concerning stability can still be explored – how does the relationship behaves according to the business cycle. For example, Owyang & Sekhposyan (2012) found that in the US economy the breakdowns in Okun's law are highly correlated with the business cycle. Although for Portugal the approach has to be somehow different from the one used for the US. Since for Portugal the number of observations is smaller and the number of periods with negative growth is also limited, an alternative method was employed in order to overcome this problem. Instead of

Graph 2: Portuguese unemployment rate and GDP growth (1974-2012)



looking to expansions or contractions, the series were divided into periods of deceleration and speedups, i.e. periods where GDP grew less (more) than the previous period. Graph 2 results from the segmentation announced and brings to surface a vast amount of important aspects to highlight. Firstly it is confirmed, once again, the instability of the relationship. Additionally, it is also concluded that the difference in the coefficients depends on the sub-sample, showing clearly different coefficients whether the economy is in a deceleration or a speedup. In periods of decelerations, a 1% GDP growth is translated into an average fall in the unemployment rate of 0.387%, while in speedups the same growth only decreases the unemployment rate in an average value of 0.210%. Additionally it is possible to see a slight difference between constant terms, assuming the same growth rate for both regressions, in periods of a speedup the unemployment rate will increase in average 0.136% more than in a period of a deceleration. Last but not least, the most surprising result is the R-square values. They indicate that the correlation between the variables is way more significant in decelerations than in speedups. Indeed, this fact can be seen by the cloud of points in the graph, in positive changes in GDP growth the group of points is more sparse while for negative changes they fit more closely to the linear trend. For decelerations, GDP growth explains 82.2% of changes in the unemployment rate, while for speedups it only explains 28.8%.

All in all, and in order to answer directly to the question purposed, the relationship between GDP growth and changes in the unemployment rate has not been stable over the years. There is also clear evidence of an increase in the correlation between the two variables, whereas Okun's coefficient almost doubled and unemployment's rate shows signs of a positive trend. Additionally, although it is not possible to state any direct finding regarding how the relationship behaves whether the business cycle is in a contraction or an expansion, there is strong evidence on different behaviors according to whether the economy has grew less or more than the previous period. Nonetheless knowing that all the seven periods where GDP growth was negative lay in the subsamples corresponding to decelerations, it is plausible or at least arguable that in periods where the economic activity is in a positive trend, GDP growth does not explain changes in unemployment rate as much as in downturns. This idea reinforces the need of output growth in the Portuguese economy, mainly nowadays, where growth has been so mild and the unemployment rate exhibits a positive trend, remaining above 15% for already more than one year.

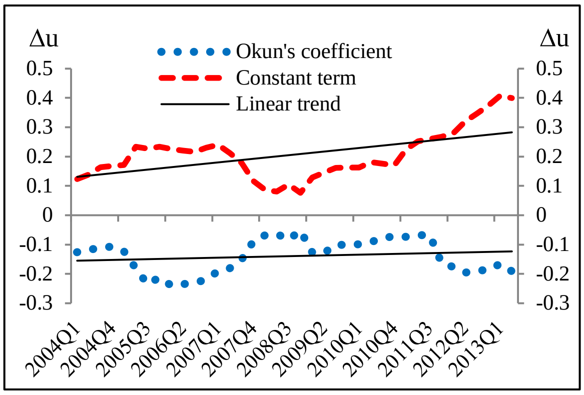
Contemporaneous analysis

In order to study the current economic situation, quarterly data is the one that gives better insights for a short-run interpretation. Though it is important to stress that the results cannot be directly comparable with the annual findings.[19] As presented in graph 3, it is possible to verify that Okun's quarterly coefficient has been somewhat stable in

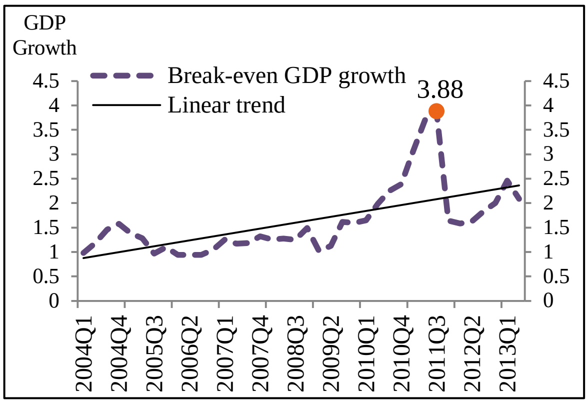
[19] Since the explanatory variable is the unemployment rate in first differences, it does not make sense to compare annually with quarterly changes.

the last seven years, floating around an horizontal line that crosses the axis in -0.156. Regarding the constant term, it verifies what was stated in the annual analysis, in which there is a positive trend in the unemployment rate. Furthermore, with the information about both coefficients it is possible to compute some interesting series and bottom line values, for instance the break-even GDP growth or the unemployment rate changes if growth assumes a certain value. Presented in graph 4 is the break-even GDP growth, or in other words, the growth rate required to have a stable unemployment rate. The main finding is that during the sovereign crisis there was a peak, whereas in order to avoid an increase in the unemployment rate, Portugal would have to have a quarterly growth rate of 3.88%, an utopic value not seen in the Portuguese economy for a long time. Additionally, there is a positive trend in the break-even GDP, mainly a consequent of the positive unemployment rate trend.

Graph 3: Rolling Windows coefficients (quarterly)



Graph 4: Break-even GDP (quarterly)



Before going to the forecasting procedures and since Okun's law is still a rule of thumb, it is newsworthy to do some descriptive analysis and explore the models and what values they provide for the law. Additionally, using quarterly data no one has ever published any values for Okun's coefficient for Portugal.[20] That said, table 2 and 3,

[20] In fact, even for Portuguese annual data only Ball et al. (2013) computed such coefficient, however it cannot be directly compared to the annual results here presented because the authors used a different approach.

present the main information obtained by models (1) and (2).[21] For each of the models was used two different specifications, with and without a dummy variable, tackling the structural break mentioned early in the stability section.[22] From model (1) is possible to take a Okun's coefficient of -0.194, i.e. if the quarterly growth is of 1%, the unemployment rate will change 0.194%, although if the break of 2008 is taking into consideration, this coefficient slightly decreases for 0.139%, while the constant term is cut by half before 2009, and doubles for 0.462% afterwards. In order to proceed to the forecasts, through the adjusted R-Squared and Schwarz Criterion one can conclude that the model with the dummy explains more properly the relationship between variables than the model without. Now looking to (2), the coefficients ω_1 and ω_2, are only to introduce the polynomial shape and do not have any meaningful value. Nevertheless one can still analyze the adjacent coefficients, computed through that same shape.[23] For both models (2) the dynamics of the relationship tend to vanish over time, although for the model without dummy the effects are inflated. The model used to

Table 2: (1) - The Static model

Changes in Unemployment rate	Without dummy	With dummy
Real GDP growth (β)	-0.194***	-0.139**
Constant term (α)	0.233***	0.119**
Dummy 2009Q1 (δ)	-	0.343***
Adj. R-Squared	0.22	0.38
Schwarz criterion	0.716	0.5395

*p<0.05, **p<0.01, ***p<0.001

Table 3: (2) - The dynamic model

Changes in Unemployment rate	Without dummy	With dummy
Polynomial coef. (ω1)	-0.106***	-0.005
Polynomial coef. (ω2)	0.068*	0.047**
Constant term (α)	0.266***	0.159**
Dummy 2009Q1 (δ)	-	0.281*
GDP growth lags	Coefficient	
0	-0.185***	-0.161***
1	-0.106***	-0.068*
2	-0.048	-0.005
3	-0.013	0.027
4		0.029
Sum of lags	-0.352***	-0.179
Adj. R-Squared	0.341	0.394
Schwarz criterion	0.637	0.577

*p<0.05, **p<0.01, ***p<0.001

[21] Taking into consideration that the VAR model (4) has not interpretable coefficients, its analysis will not be described.
[22] The inclusion of any effects of the business cycle as explanatory variable was tested but it was only significant for the annual data.
[23] The numbers of latent coefficients are different across regressions due to the fact that depending on the inclusion of the dummy variable Schwarz Criterion changed, thus both results showed are already the regressions for each Schwarz Criterion is the smallest possible. These are still comparable because the samples are the same.

forecasts will be the one with the dummy, because even though the latent coefficients are not as significant as without the dummy, the explanatory power of the dummy overcomes the information provided by the coefficients. In the model without dummy, the contemporaneous impact of 1% GDP growth in the unemployment rate is -0.185%, while in the dummy model it is only -0.161%. This dynamic model (2) introduces an idea that was not explored so far in this study, namely that the labor market lags GDP growth, i.e. one quarter is not enough to capture all the impact that growth has on the labor market. Indeed, when looking to the one quarter lagged coefficients one can see that both are significant at 5%. Moreover, thanks to incorporating dynamics in the analysis one can also explore the overall impact over time. For instance in the model without dummy, a growth of 1% in GDP today, will have a cumulative effect of -0.352% in unemployment rate. Although the same cannot be concluded for the model with dummy, the outlying lags take away the significance of the sum of lags presented, thus not having a significant meaning.

Forecasts

Table 4: Forecasting Analysis - 1 quarter ahead forecasts (1999Q2 - 2013Q2)

	(1) Static		(2) Dynamic		(4) VAR
	(6)	(7)	(6)	(7)	
MSPE (Baseline model (5) = 100%)	89.133%	96.679%	80.402%	85.328%	88.904%
Prediction errors standard deviation	94.410%	98.326%	89.667%	92.373%	94.289%
DM (p-values)	8.340%	63.170%	8.200%	9.640%	54.300%

Table 4 resumes all the information of the forecasting analysis, it exhibits the MSPE, standard deviation of the forecasting errors and DM p-values for the models (1), (2) and (4) in comparison to the baseline model (5). Additionally, for the static model (1) and the dynamic model (2), there are two different forecasting regressions of the contemporaneous values of GDP growth, models (6) and (7). The first finding taken from it is that all models containing Okun's information, i.e. (1),(2) and (4), have lower MSPE's than the baseline model (5). In other words it is likely that GDP growth contributes to produce good forecasts, at least in the short run. Furthermore, regardless of what GDP growth forecasting model is used, the dynamic model (2) is the one that provides the forecasts with smaller MSPE's, followed by the VAR model (4) and in third is the static model (1). Even though, through the MSPE's one can rank the models, it is still important to check if the differences are statistically significant. Therefore, in order to compare them, DM tests were computed and once again the results have as bottom line the baseline model (5). On one hand all the coefficients are positive, indicating what was previously stated that all models have lower MSPE's than the baseline model (5).[24] However not all those differences are statistically significant. The static and dynamic models (1) and (2) using growth as a function of CCI (6) and the dynamic model (2) with the ARMA process (7) are significant at 10%. The remaining, static model (1) with the ARMA process (7) and the VAR model (4), do not present evidence that they provide better forecasts than the baseline model (5).

In the end, the conclusions that can be taken are that using information about the GDP growth when forecasting changes in the unemployment rate is useful when this predictions are for short-run periods.[25] Additionally, despite not all models provide better statistical significant forecasts than an autoregressive model, there is no evidence that they perform worse forecasts neither. Lastly, from the models studied, the one that computed better forecasts was the dynamic model (2), using CCI as a leading indicator of contemporaneous Growth (7).

[24] DM test outputs are presented in the Appendix.
[25]The analysis can be performed for the long-term as well, but since the relationship between the variables is not stable, it was decided not to perform them in this project.

V - Conclusion and discussion

All in all, on one side, the historical analysis introduced how the Okun's relationship varied throughout the years, with particular emphasis on the movements during the more recent crisis. On the other side, it provided strong evidence on how GDP growth and the unemployment rate are correlated. The first main result is that the relationship between changes in unemployment and GDP growth is not stable, going in line with the majority of the current literature. Since the Carnation revolution Okun's coefficient changed from around 0.213% to 0.370% in 2012, suggesting an increase in the correlation between the variables. Further, this coefficient not only as been increasing, but tends to be higher in periods where the economy is decelerating, or in other words, when growth has decreased when compared to the period before. Indeed, the variables are more correlated in decelerations than in accelerations. A possible explanation for this event is the one supported by the economic theory on wage rigidity, where adjustments are made through a decline in employment because the downward adjustment in wages is sluggish. Additionally, in accelerations unemployment rate still fluctuates regardless of GDP growth, indicating that structural unemployment is always present and therefore exists a smaller correlation between variables. Both this findings are in line with the reasoning supporting the extreme importance of output growth, especially in what concerns unemployment in slowdown periods, in which the variables exhibit a higher correlation and growth can decrease unemployment substantially. Furthermore, as an evidence of what was stated, during the sovereign debt crisis, the break-even GDP growth that would sustain the increasing unemployment rate reached a peak of 3.88%, a value not seen for Portugal in a long time. Last but not least, even though the relationship between the variables is not stable, it still provides fruitful information when performing short-run forecasts. All the models containing GDP growth as explanatory variable constructed predictions with lower MSPE’s than an univariate model. When comparing the statistically difference between the forecasts in each model, not every model performed better than the baseline model (5), though none performed worse neither.

Notwithstanding, these findings are just a drop in the ocean in what concerns the analysis between those two variables. In order to fully understand this relationship and provide further guidance in policy-making it is required to step inside the labor market and learn how its engine works – mainly through the analysis of laws, contracts, unions, labor force characteristics, etc. The point in this research is not showing the results and accept them has isolated facts, but instead create an empirical base that can support further research in the subject. Finally, even though it was concluded that Okun’s law brings relevant information when forecasting, the model are still insipient and weak when capturing all the dynamics of the series and therefore forecasting. Henceforth, when computing forecasts for the unemployment rate, not only is useful to use GDP growth but also to construct more elaborated models with additional information. A possible next step could be for example, to study the explanatory power of EPL in the relationship between the variables for the Portuguese economy, which would be a way to introduce labor market characteristics in the analysis.

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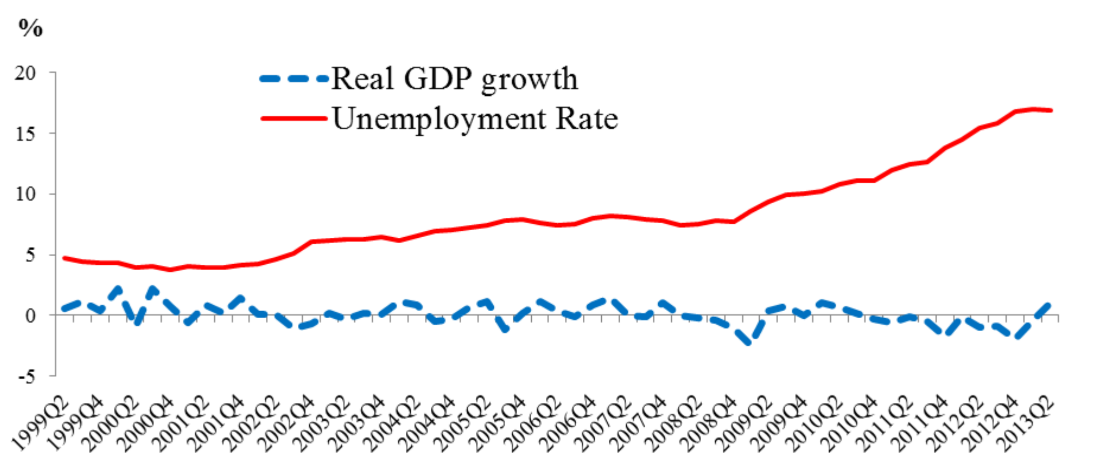
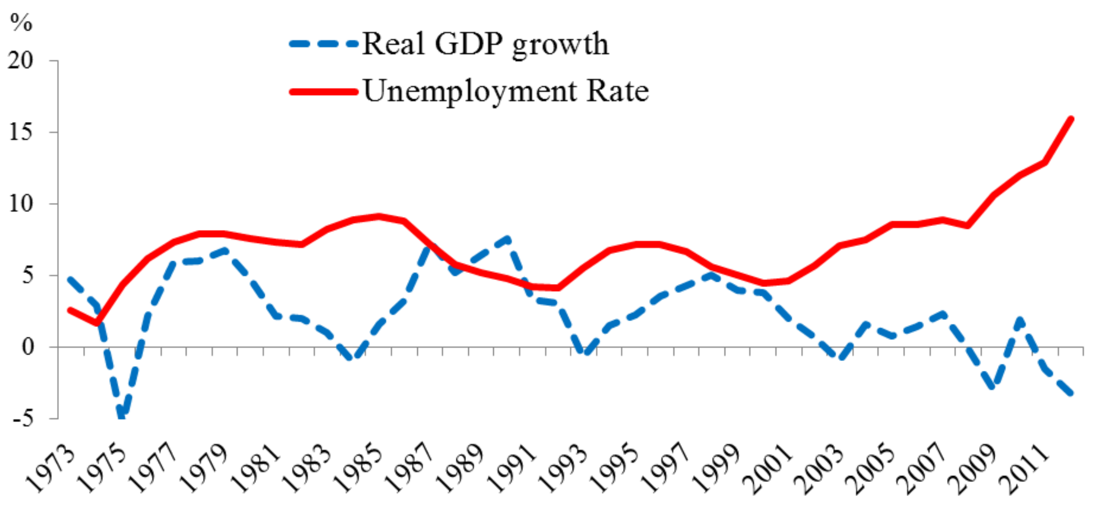
Appendix

Appendix: Graph I - Quarterly real GDP growth and Unemployment rate series (1992Q2-2013Q2)



Source: OECD

Appendix: Graph II - Annually real GDP growth and Unemployment rate series (1974-2012)



Source: AMECO and OECD

Appendix: Output I - BP break test in Okun's relationship

Multiple breakpoint tests
Compare information criteria for 0 to M globally determined breaks
Date: 10/02/13 Time: 18:51
Sample: 1999Q1 2013Q2
Included observations: 57
Breakpoint variables: C G
Break test options: Trimming 0.15, Max. breaks 5

Schwarz criterion selected breaks:	1
LWZ criterion selected breaks:	0

Break...	# of Coefs.	Sum of Sq. Resids.	Log-L	Schwarz* Criterion	LWZ* Criterion
0	2	5.926757	-16.36763	-2.121713	-2.030652
1	5	4.431188	-8.079565	-2.199730	-1.969566
2	8	4.065181	-5.622596	-2.073147	-1.700546
3	11	3.457499	-1.008078	-2.022268	-1.503474
4	14	3.174722	1.423694	-1.894801	-1.225552
5	17	3.014452	2.900051	-1.733811	-0.909227

* Minimum information criterion values displayed with shading

Estimated break dates:
1: 2009Q1
2: 2001Q3, 2009Q1
3: 2002Q1, 2006Q2, 2009Q1
4: 2002Q1, 2006Q2, 2009Q1, 2011Q1
5: 2002Q1, 2004Q2, 2006Q2, 2009Q1, 2011Q1

Appendix: Output II - The static model (1)

Dependent Variable: DU
Method: Least Squares
Date: 10/29/13 Time: 15:27
Sample (adjusted): 1999Q2 2013Q2
Included observations: 57 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.119410	0.048747	2.449584	0.0176
G	-0.138461	0.044676	-3.099199	0.0031
D2009Q1	0.343058	0.088082	3.894752	0.0003

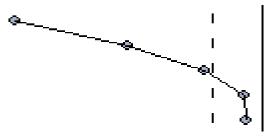
R-squared	0.401845	Mean dependent var	0.213954
Adjusted R-squared	0.379691	S.D. dependent var	0.371662
S.E. of regression	0.292720	Akaike info criterion	0.431996
Sum squared resid	4.626993	Schwarz criterion	0.539525
Log likelihood	-9.311887	Hannan-Quinn criter.	0.473785
F-statistic	18.13877	Durbin-Watson stat	2.040118
Prob(F-statistic)	0.000001		

Appendix: Output III - The dynamic model (2)

Dependent Variable: DU
Method: Least Squares
Date: 10/29/13 Time: 17:20
Sample: 2001Q4 2013Q2
Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.159216	0.058924	2.702055	0.0098
D2009Q1	0.281110	0.109575	2.565457	0.0139
PDL01	-0.005298	0.029754	-0.178067	0.8595
PDL02	0.047417	0.014068	3.370508	0.0016

R-squared	0.433634	Mean dependent var	0.275425
Adjusted R-squared	0.394120	S.D. dependent var	0.368131
S.E. of regression	0.286547	Akaike info criterion	0.419437
Sum squared resid	3.530697	Schwarz criterion	0.576897
Log likelihood	-5.856780	Hannan-Quinn criter.	0.478690
F-statistic	10.97423	Durbin-Watson stat	1.795968
Prob(F-statistic)	0.000018		



Lag Distribution of G	i	Coefficient	Std. Error	t-Statistic
	0	-0.16100	0.04374	-3.68046
	1	-0.06793	0.02634	-2.57906
	2	-0.00530	0.02975	-0.17807
	3	0.02690	0.03108	0.86543
	4	0.02867	0.02175	1.31821
	Sum of Lags	-0.17866	0.10806	-1.65333

Appendix: Output IV - The VAR model (4)

Vector Autoregression Estimates
Date: 10/15/13 Time: 15:47
Sample (adjusted): 1999Q3 2013Q2
Included observations: 56 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	DU	G
DU(-1)	0.195623	-0.486625
	(0.13786)	(0.37829)
	[1.41901]	[-1.28637]
G(-1)	-0.142106	0.084745
	(0.05559)	(0.15254)
	[-2.55636]	[0.55556]
C	0.186454	0.192043
	(0.05545)	(0.15217)
	[3.36234]	[1.26204]
R-squared	0.226155	0.060486
Adj. R-squared	0.196954	0.025032
Sum sq. resids	5.950594	44.80743
S.E. equation	0.335075	0.919469
F-statistic	7.744594	1.706063
Log likelihood	-16.68846	-73.21718
Akaike AIC	0.703159	2.722042
Schwarz SC	0.811660	2.830543
Mean dependent	0.217741	0.092092
S.D. dependent	0.373914	0.931198

Determinant resid covariance (dof adj.)	0.076707
Determinant resid covariance	0.068709
Log likelihood	-83.94042
Akaike information criterion	3.212158
Schwarz criterion	3.429160

Appendix: Output V - The baseline model (5)

Dependent Variable: DU
Method: Least Squares
Date: 11/11/13 Time: 23:38
Sample (adjusted): 1999Q4 2013Q2
Included observations: 55 after adjustments
Convergence achieved after 28 iterations
MA Backcast: 1999Q2 1999Q3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.115708	0.020976	5.516188	0.0000
D2009Q1	0.324944	0.066063	4.918736	0.0000
AR(1)	1.811597	0.088415	20.48963	0.0000
AR(2)	-0.872761	0.094987	-9.188168	0.0000
MA(1)	-1.879874	0.049976	-37.61539	0.0000
MA(2)	0.885718	0.046371	19.10073	0.0000

R-squared	0.423052	Mean dependent var	0.227359
Adjusted R-squared	0.364180	S.D. dependent var	0.370304
S.E. of regression	0.295274	Akaike info criterion	0.500846
Sum squared resid	4.272164	Schwarz criterion	0.719828
Log likelihood	-7.773267	Hannan-Quinn criter.	0.585528
F-statistic	7.185936	Durbin-Watson stat	1.989769
Prob(F-statistic)	0.000041		

Inverted AR Roots	.91-.23i	.91+.23i
Inverted MA Roots	.94-.05i	.94+.05i

Appendix: Output VI - The growth CCI model (6)

Dependent Variable: G
Method: Least Squares
Date: 12/29/13 Time: 15:39
Sample (adjusted): 1999Q2 2013Q2
Included observations: 57 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.021230	0.278912	3.661485	0.0006
CI(-1)	0.028780	0.007988	3.602838	0.0007

R-squared	0.190944	Mean dependent var	0.099599
Adjusted R-squared	0.176234	S.D. dependent var	0.924585
S.E. of regression	0.839168	Akaike info criterion	2.521645
Sum squared resid	38.73115	Schwarz criterion	2.593331
Log likelihood	-69.86689	Hannan-Quinn criter.	2.549505
F-statistic	12.98044	Durbin-Watson stat	2.113663
Prob(F-statistic)	0.000677		

Appendix: Output VII - The growth ARMA model (7)

Dependent Variable: G
Method: Least Squares
Date: 12/29/13 Time: 17:51
Sample (adjusted): 1999Q3 2013Q2
Included observations: 56 after adjustments
Convergence achieved after 29 iterations
MA Backcast: 1999Q2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.250011	0.066005	3.787760	0.0004
D2008Q1	-0.529577	0.124598	-4.250277	0.0001
AR(1)	0.764855	0.080764	9.470240	0.0000
MA(1)	-0.967792	0.022837	-42.37757	0.0000

R-squared	0.241866	Mean dependent var	0.092092
Adjusted R-squared	0.198128	S.D. dependent var	0.931198
S.E. of regression	0.833863	Akaike info criterion	2.543253
Sum squared resid	36.15701	Schwarz criterion	2.687921
Log likelihood	-67.21109	Hannan-Quinn criter.	2.599341
F-statistic	5.529825	Durbin-Watson stat	1.742989
Prob(F-statistic)	0.002263		

Inverted AR Roots	.76
Inverted MA Roots	.97

Appendix: Output VIII - DM test - static model (1)) with contemporaneous growth explained by an ARMA process (7) vs baseline model (5)

Dependent Variable: D_OKUN
Method: Least Squares
Date: 12/29/13 Time: 19:16
Sample (adjusted): 2004Q3 2013Q2
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003423	0.011144	0.307129	0.7606

R-squared	0.000000	Mean dependent var	0.003423
Adjusted R-squared	0.000000	S.D. dependent var	0.066865
S.E. of regression	0.066865	Akaike info criterion	-2.544898
Sum squared resid	0.156482	Schwarz criterion	-2.500912
Log likelihood	46.80817	Hannan-Quinn criter.	-2.529546
Durbin-Watson stat	1.615156		

Appendix: Output IX - DM test - dynamic model (2) with contemporaneous growth explained by an ARMA process (7) vs baseline model (5)

Dependent Variable: D_OKUN
Method: Least Squares
Date: 12/29/13 Time: 17:58
Sample (adjusted): 2004Q3 2013Q2
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004979	0.010295	0.483619	0.6317

R-squared	0.000000	Mean dependent var	0.004979
Adjusted R-squared	0.000000	S.D. dependent var	0.061769
S.E. of regression	0.061769	Akaike info criterion	-2.703445
Sum squared resid	0.133539	Schwarz criterion	-2.659458
Log likelihood	49.66200	Hannan-Quinn criter.	-2.688092
Durbin-Watson stat	1.439500		

Appendix: Output X - DM test - dynamic model (2) with contemporaneous growth explained by CCI (6) vs baseline model (5)

Dependent Variable: D_PDL
Method: Least Squares
Date: 11/26/13 Time: 16:25
Sample (adjusted): 2004Q3 2013Q2
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.029382	0.016410	1.790526	0.0820

R-squared	0.000000	Mean dependent var	0.029382
Adjusted R-squared	0.000000	S.D. dependent var	0.098458
S.E. of regression	0.098458	Akaike info criterion	-1.770980
Sum squared resid	0.339292	Schwarz criterion	-1.726994
Log likelihood	32.87765	Hannan-Quinn criter.	-1.755628
Durbin-Watson stat	1.379354		

Appendix: Output XI - DM test - static model (1) with contemporaneous growth explained by CCI (6) vs baseline model (5)

Dependent Variable: D_OKUN
Method: Least Squares
Date: 11/26/13 Time: 16:23
Sample (adjusted): 2004Q3 2013Q2
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.016292	0.009141	1.782311	0.0834

R-squared	0.000000	Mean dependent var	0.016292
Adjusted R-squared	0.000000	S.D. dependent var	0.054847
S.E. of regression	0.054847	Akaike info criterion	-2.941144
Sum squared resid	0.105288	Schwarz criterion	-2.897157
Log likelihood	53.94059	Hannan-Quinn criter.	-2.925792
Durbin-Watson stat	1.822219		

Appendix: Output XII - DM test - VAR model (4) vs baseline model (5)

Dependent Variable: D_VAR
Method: Least Squares
Date: 11/26/13 Time: 16:24
Sample (adjusted): 2004Q3 2013Q2
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.016636	0.027099	0.613891	0.5433

R-squared	0.000000	Mean dependent var	0.016636
Adjusted R-squared	0.000000	S.D. dependent var	0.162593
S.E. of regression	0.162593	Akaike info criterion	-0.767747
Sum squared resid	0.925279	Schwarz criterion	-0.723760
Log likelihood	14.81944	Hannan-Quinn criter.	-0.752394
Durbin-Watson stat	2.178267		